# Mars Atmos-Spheres

*Improving Mars Atmospheric Knowledge*

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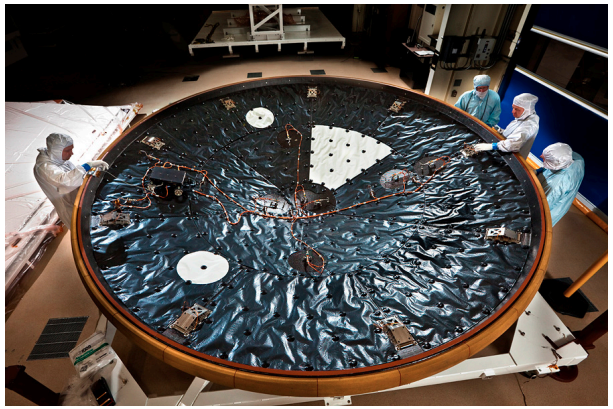
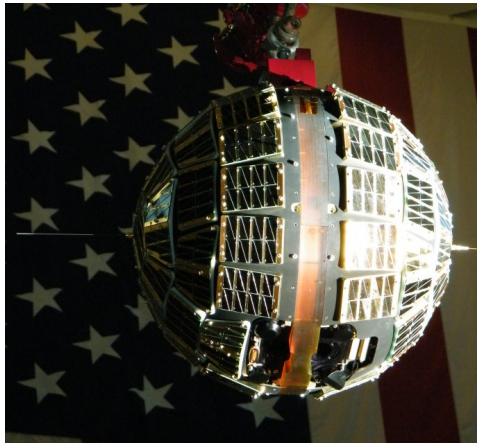
# Motivation

- **MEPAG Goal IV.A.1A**: Determine the aspects of the atmospheric state that affect aerocapture, Entry, Descent and Landing (EDL) and launch from the surface of Mars. This includes the variability on diurnal, seasonal and inter-annual scales from ground to > 80 km in both ambient and various dust storm conditions. The observations are to directly support engineering design and also to assist in numerical model validation, especially the confidence level of the tail of dispersions (>99%).
  - It would be prudent to instrument all Mars atmospheric flight missions to extract required vehicle design and environment information.
  - Each landed mission to Mars has the potential to gather data that would significantly improve our models of the Martian atmosphere and its variability. It is thus desired that each opportunity be used to its fullest potential to gather atmospheric data.
  - Reconstructing atmospheric dynamics from tracking data is useful but insufficient. Properly instrumenting entry vehicles would be required.

- Secondary measurements are also possible



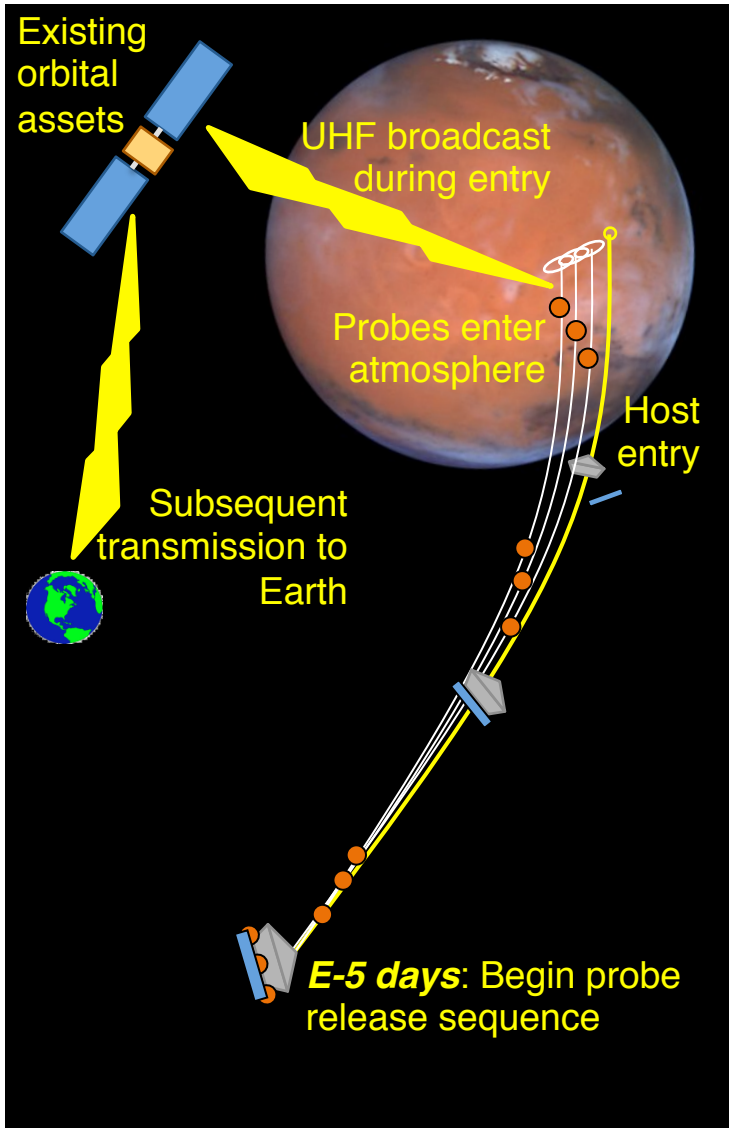
MEDLI (onboard MSL) provided forebody pressure and thermal response data that was used to improve models and knowledge of Mars aerodynamics, thermal response & atmosphere.



Launched in Sept 2013, CU-Boulder DANDE spacecraft collected drag data 200-300 miles above the Earth. Series of earlier NRL missions did the same.

# Technical Concept

- Entry probes are deployed prior to final targeting maneuver and enter away from host spacecraft
- Entry probe design selected to eliminate need for attitude control and minimize aerodynamic uncertainty
- Each probe includes uniform TPS, battery, UHF radio, 3-axis accelerometer, g-triggered wake-up circuit. Placement of components provides needed cg control.
  - Honeywell-QA-3000-class accelerometer with dynamic range from 16mg to 40g (Mars Pathfinder)
  - TPS must be RF-transparent
- Acceleration data transferred to orbital assets during entry; post-flight analysis will reconstruct Mars atmospheric density over trajectory
- Differential ranging allows wind profile estimation, but requires additional instrumentation
- System can also be used to explore ground-to-flight traceability of a variety of TPS materials
- Baseline concept does not rely on surface impact survival; intelligent release timing may also allow investigation of subsurface exposed by impact

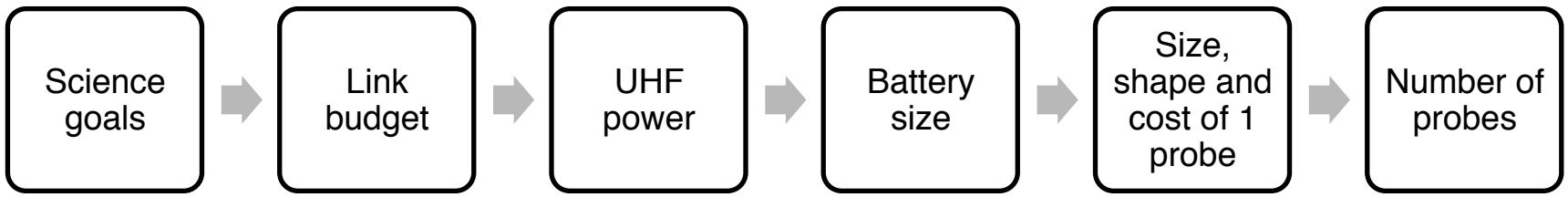


# System Definition and Key Trades

- Science goals
  - Density only
  - Density and winds
  - Auxiliary TPS experiments
  - Auxiliary surface impact objective

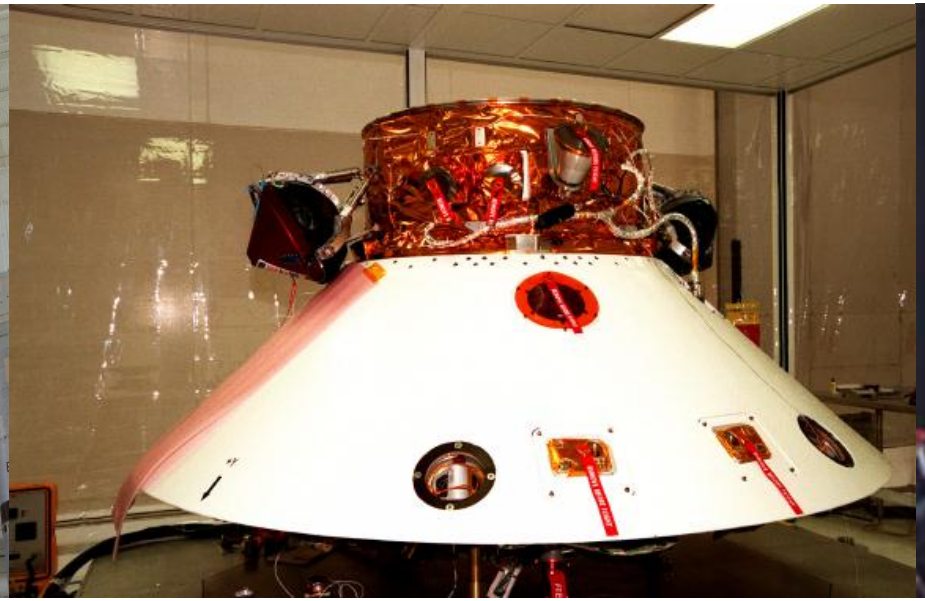
| **Preliminary Budget** (single probe) | |
|---|---|
| Mass | 5 kg |
| Diameter | 20 cm |
| β | 160 kg/m$^2$ |
| Power | 20 W-hr |

- Deployment strategy (must not adversely impact host)
- Power requirements: battery size and UHF telecom requirements connect science return and cost
- Shape trade: Sphere has manufacturing, payload volume, structural efficiency, and known, uniform drag coefficient advantages; DS-2 geometry has TPS mass efficiency and aero reorientation advantages
- Number of probes is a cost-complexity trade (attachment, release mechanism complexity)



# Anticipated System Development Challenges

- Interface and deployment from host spacecraft (5-10 kg dispenser depending on number of probes)
- Data accommodation during entry with orbital assets



# Summary and Benefits

- Significantly expands data sets for Mars atmosphere reconstruction
  - Several probes deployed on a single flight would double the Mars atmospheric dataset, resulting in significant uncertainty reduction and improved model validation
- Probes may also serve as thermal protection system testbed to investigate ground-to-flight traceability
- Probes may also be designed to function as surface impactors
- Concept is a low-cost, low-mass approach to gaining this data set with minimal impact to the host spacecraft
  - Atmo-Spheres likely carried on cruise stage